A Practical Approach to Data Modeling using CCO (Common Core Ontologies)
Motivation for our Research

• We are involved in several US Army projects that require creating new logical data models and aligning several existing logical data models for ABCS (Army Battle Command Systems).
  – All the models pertain to the same domain, land combat.
  – The alignment is needed to integrate multiple ABCS.
  – The new logical models are being defined as a common model for a collection of ABCS.

• Both of the modeling efforts use an implicit domain model of land combat.
  – The implicit domain model consists of concepts defined in Army standards and doctrine.
  – Use of an implicit domain model increases the level of effort of the logical modeling activities.

• We believe a formal domain model will improve the efficiency of the modeling activities.
  – Single source for semantics
  – Interpretation of the concepts requires less domain expertise than an implicit domain model.
Land Combat Domain Model

• The Land Combat domain model will be a lexicon of the informational concepts of land combat.

• Main objectives:
  – The Land Combat domain model has to be translatable into logical models.
    • The Land Combat domain model has to be defined in such a way that software engineers can define mappings between the logical model and the domain model.
    • The software engineers shouldn’t require any experience in ontology development to create the mappings.
  – The Land Combat domain model has to be semantically rich.
CCO as a Meta-model

• We seek to achieve semantic richness by developing the Land Combat domain model using an ontological framework.

• We use CCO as a meta-model for the domain model.
  – In other words, we develop a consistent method for adding assertions about land combat informational concepts to CCO.

• CCO is a collection of upper-level, mid-level, and lower-level ontologies that provide a framework for modeling the world.
  – Based on BFO (Basic Formal Ontology)
  – Defined in OWL
  – Developed in part by US Army CERDEC.
The Land Combat Domain Model will be a Domain Ontology that extends the *Information Entity Ontology*.
• Informational concepts are partitioned into two hierarchies, *Information Bearing Entities* and *Information Content Entity*.

• Information Content Entity
  – A concept that represents the information about an entity.

• Information Bearing Entity
  – A concept that represents how information about an entity is organized.
  – Content Entities inhere in Bearing Entities.
  – Supports the ability to “share” information content amongst multiple containers of that information.
Modeling Methodology for the Land Combat Domain Model

- We partition information about entities into three categories.
  
  **Entity Artifact**
  - An informational concept that asserts information about rigid properties of an entity.
  - Example: Maximum speed of an infantry fighting vehicle

  **Entity Report**
  - An informational concept that captures observations about an entity’s state at a given time.
  - Example: Position report of infantry fighting vehicle.

  **Entity Representation**
  - An informational concept describing human understandable signs and symbols which can be presented to a human actor via some sensory medium.
  - Examples: MIL-STD 2525 symbol of an infantry fighting vehicle.

- We only model Entity Artifacts and Entity Reports in CCO.
Modeling Land Combat as Informational Concepts

- Example land combat informational concepts
  - Tank, Infantry Fighting Vehicle, Radar
  - BTR-90, YW 531H
  - Ground track, Air track
  - caliber, rate of fire, ground pressure
  - 7.62 mm, unclassified, north, south

- Relationships
  - Subsumption
  - Whole-part
  - Affiliations

- Land combat informational concepts are defined as individuals instead of classes.
  - Information Bearing Entities: Artifacts and Reports
  - Information Content: Terms used in the definition of informational concepts.
Sample of Ground Equipment Entities

Legend
- ●: Entity Artifact
- ●: Entity Record
- ●: Type Code Concept
- ●: Atomic Term
- ●: Relationship

- cruisings_range
  - has_value: 500km
- troop_capacity
  - has_attribute: 2/4
- has_feature
  - specialization_of : heavy_MG
- YW_531H
- has_feature
  - specialization_of : Type_54
- has_feature
  - specialization_of : NSV
- has_feature
  - has_feature: radio
- BTR-90
- has_feature
  - generalization_of: Type_889
- 2A42
- armament
  - has_attribute: 30-mm_automatic_gun
- rate_of_fire
  - has_attribute
    - has_attribute: 550_cyclic_in_bursts
Sample of Land Combat Informational Concepts and Their Relationships

- Informational concepts and their relationships are modeled as A-Box assertions.
Mapping the CCO Domain Model to ECore

- Mapping to Ecore is straightforward
  - We created the Domain Model using some of the domain modeling concepts in Ecore.
- Land Combat Information Entity becomes a class in Ecore or an enumeration class in Ecore.
  - The ‘generalization of’ and ‘specialization of’ properties determine its subclasses and parent class.
    - If A generalization of B is a triple, then the Ecore class corresponding to A, will be a subclass of the Ecore class corresponding to B.
  - The ‘generalization of’ and ‘specialization of’ properties determine enumeration literals.
    - If A generalization by X and A generalization by Y are triples, then X and Y are the enumerations of Enumeration class A.
    - No attributes defined for the class corresponding to A
- Attributes
  - ‘has feature’, ‘has attribute’ and ‘has value’ used to define attributes in
  - ‘has code’ used to define Enumeration attributes of Type Codes
Mapping the CCO Domain Model to NIEM

- **NIEM Types**
  - Each MC Entity individual will be a NIEM type
  - Elements of types are determined by the objects in triples
    - Objects of ‘has feature’ and ‘has attribute’ will be come composite elements
    - Objects of ‘has value’ will be come scalar elements
    - Use ‘generalization of’ and ‘specialization of’ for inheritance

- **NIEM Code Lists**
  - Objects in triples of ‘has code’ become Code Lists
    - Members are determined by objects of ‘enumerated by’

- **NIEM Association Types**
  - Relation individuals become Association Types

- **NIEM Metadata**
  - A logical modeler determines whether an object of a ‘has feature’ triple should be considered Metadata.

- **NIEM Augmentation and Extension**
  - Augmentation point and extensions are determined from ‘generalization of’ and ‘specialization of’.
  - The logical modeler determines whether to create an augmentation point or an extension.
Conclusion

• Creation of a domain model for land combat in progress.
• Software engineers will be able to create intuitive mappings between the domain model and logical models.
• The Land Combat domain model may be non-conformant.
  – Sacrifice conformance for intuitive mappings.